

Analyzing the impact of gamification on a mHealth application for treating urinary incontinence in prostate cancer patients

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Abstract:

It is estimated that approximately one month after radical prostatectomy, a surgical procedure to remove the prostate, 80% of men experience urinary incontinence (UI). Behavioral therapy, which involves modifying the patient's lifestyle habits, along with physical treatments such as exercises to strengthen the pelvic muscles and complementary behavioral therapies with techniques associated with personal beliefs, can be used to treat urinary incontinence in this context. IUProst® is a mobile health application (mHealth) designed to promote self-care and improve the quality of life for men who suffer from urinary incontinence due to prostate removal surgery caused by prostate cancer. Version 2.0 of IUProst® was released with several improvements, including adding gamification elements to encourage patient engagement in the execution of behavioral treatment exercises for urinary incontinence. This article presents the IUProst® application and analyzes the data generated by its use to understand the level of improvement that patients have experienced regarding urinary incontinence. It also examines the impact of gamification on exercise execution. The results demonstrate the clinical improvement in patients' involuntary loss of urine, presenting less urine flow and reducing the feeling of urgency to go to the bathroom after using IUProst®. A comparative analysis is also included, considering the 60 days before and after the implementation of the gamification elements. During the 120 days considered, gamified data was collected for 60 days, and this period accounted for 83% of all exercises performed, despite the similar number of users using the application. The significant increase in exercise performance during the gamified period suggests that the gamification positively supported patient engagement.

Keywords: Gamification, Self-care, Urinary incontinence, Prostate Cancer, IUProst®, mHealth, Engagement

1 Introduction

According to the National Cancer Institute (INCA), prostate cancer is the second most incident type in all regions of Brazil, representing 29.2% of tumors affecting the Brazilian male population, with an estimated 72 thousand new cases in Brazil in the triennium 2022-2025, second only to non-melanoma skin cancer (INCA [2022]).

For cases of localized and potentially curable prostate cancer, one of the possible treatments is the removal of the entire prostate gland and seminal vesicles, known as radical prostatectomy (RP) (Mungovan *et al.* [2021]; Azevedo *et al.* [2021]; Izidoro and Soares [2021]). The treatment choice is made through dialogue between the medical team and the patient, considering the benefits and possible complications. RP is the preferred treatment in cases where the disease is not in advanced stages (Estevam [2022]). Despite its benefits, the removal surgery can lead to complications, with urinary incontinence (UI) and involuntary urine loss being the most common, estimated to affect 80% of men in the first 30 days after surgery (Abrams *et al.* [2017]).

Urinary incontinence can significantly affect an individual's quality of life, as it is associated with the risk of de-

pression, anxiety, sexual limitations, low self-esteem, fear, and shame (Bernardes *et al.* [2019]). Possible treatments include surgical procedures, pharmacological approaches, and behavioral therapies. The International Continence Society (ICS) recommends adopting behavioral change strategies, pelvic floor training, and complementary therapies (Abrams *et al.* [2017]).

This article is part of a research project conducted by the Nursing School of the Universidade Federal de Minas Gerais (UFMG) in collaboration with the Health Informatics Laboratory of the Institute of Informatics at the Universidade Federal de Goiás (UFG). The research project, in its initial phase, originated from two doctoral theses (Azevedo *et al.* [2021]; Izidoro and Soares [2021]), which led to the development of a booklet as a cognitive-behavioral program for treating urinary incontinence in prostate cancer patients undergoing radical prostatectomy. Subsequently, along with the research of Estevam [2022], the IUProst®¹, a mHealth application based on the cognitive-behavioral program, was developed to promote self-care and improve the quality of life for men suffering from urinary incontinence due to prostate removal

¹<https://www.iuprost.com.br/>

surgery caused by prostate cancer.

With the use of IUProst® on Android-based smartphones, patients can perform sequences of exercises to strengthen pelvic muscles, aiming for the recovery of urinary control, and gain literacy about the disease and healthy habits (Anjos *et al.* [2022]; Oliveira *et al.* [2022]). Version 1.0 of IUProst® was released in October 2022, emphasizing exercise execution and assisting patients in better understanding the disease they are facing. In July 2023, version 2.0 of IUProst® was released, incorporating several improvements, including adding game elements to encourage patient engagement in executing behavioral treatment exercises for urinary incontinence.

Gamification is defined as the application of game elements in non-game contexts to keep the user motivated in performing activities within a gamified software (Oliveira and Carvalho [2020b]; Deterding *et al.* [2011]; van Gaalen *et al.* [2021]). Gamified applications aim to stimulate users to change their behaviors towards a specific goal, strengthening their intrinsic motivation and directing them to achieve it (Yousefi and Mirkhezri [2020]; Bucchiarone *et al.* [2019]).

This article aims to present the IUProst® application and analyze the data generated by its use to understand the level of improvement that patients have experienced regarding urinary incontinence. Additionally, it analyzes the impact of gamification on patient engagement in exercise execution, comparing data generated during the period when the application did not have game elements with data collected after gamification with points to each exercise practice, daily goals, and feedback on the daily and weekly progress of exercise execution.

The article is an extended and revised version of a paper published at the XXII Brazilian Symposium on Games and Digital Entertainment (SBGames) (Anjos *et al.* [2023]). Among the main extensions is the comparative analysis of data generated by versions 1.0 and 2.0 of IUProst®, an analysis of patient improvement after a treatment period, a description of the characteristics of the analyzed users, as well as a demonstration of the difference in engagement between the use of the gamified application instead of non-gamified version. Data generated by the application for August 2023 was also added to equalize 60 days of exercise execution using the non-gamified version and 60 days of data collection of exercise completion during the period with gamification elements in place.

In addition to this introduction, the article is organized into four sections. Section 2 provides background information on concepts related to treating male urinary incontinence, mHealth, self-care, and gamification. Section 3 describes the application, its versions, the implementation of exercises with game elements, and the application's scoring system. Section 4 presents the results regarding using versions 1.0 and 2.0 of the application. Finally, Section 5 covers the conclusions and future work.

2 Background

This section presents the behavioral treatment that formed the basis for IUProst®'s treatment and introduces the con-

cepts of self-care, mHealth, and gamification.

2.1 The Treatment for Male Urinary Incontinence

Within a month of undergoing radical prostatectomy (RP) surgery, approximately 80% of men experience urinary incontinence (UI) (Abrams *et al.* [2017]). Even after ninety days post-surgery, men who do not receive a therapeutic option may still experience moderate or severe UI. Up to six months post-surgery, approximately 57% of men may exhibit involuntary urine loss (Izidoro *et al.* [2022]).

One way to address urinary incontinence in this context is through behavioral therapy, involving lifestyle changes for the patient, along with physical therapies such as pelvic muscle strengthening exercises and complementary behavioral therapies with techniques associated with personal beliefs. Once proven effective, this type of therapy has been employed in treating various diseases (Abrams *et al.* [2017]).

This treatment involves collecting information about the patient's daily life, including physical exercises like bladder training for muscle strengthening (Estevam [2022]). The exercises for the proposed treatment are defined as a program of voluntary contractions of the pelvic floor guided by healthcare professionals, aiming to maintain muscle strength to support pelvic organs and, consequently, improve bladder function, coordination, pressure, and urethral closure (Frawley *et al.* [2017]).

The booklet titled "Guidelines Manual on Urinary Incontinence Post-Radical Prostatectomy" was produced from the doctoral thesis titled "Effectiveness of Pelvic Muscle Training Associated with Auricular Acupuncture in Controlling Urinary Incontinence post-Radical Prostatectomy: Randomized Clinical Trial" by Azevedo *et al.* [2021]. The purpose of the booklet is to assist the patient in understanding more about the disease they are facing.

During the first three days of treatment, it is recommended that the patient fill out some forms of the so-called "bladder diary" daily. This diary includes information such as types and quantities of liquids ingested, estimated urine volume, whether urine loss or leakage occurred during the day, and the registration of pad, liner, or diaper changes. These forms are necessary to understand the patient's routine, as the treatment requires behavioral changes, including lifestyle modifications (Estevam [2022]; Azevedo *et al.* [2021]).

Continuous tracking of fluid intake, especially during the initial stages of treatment, is essential, as many patients refrain from consuming liquids, believing that it contributes to increased urination (Abrams *et al.* [2017]). Specifying the type of fluid ingested is necessary since studies indicate that fluids containing caffeine, alcoholic beverages, and diuretics can interfere with bladder muscle behavior.

The booklet covers various topics to assist the patient in changing habits and better understanding their health conditions. These topics include what radical prostatectomy is, potential post-prostate removal surgery outcomes, what UI is, why surgery may cause UI, how long UI may persist, how to treat UI, what to avoid, what to do, exercises for pelvic muscles, and essential tips such as control measures for urgency and dribbling UI (Estevam [2022]; Azevedo *et al.* [2021]).

This information is provided as printed content, illustrations, and a guide for exercise execution.

The pelvic floor strengthening exercises proposed by the treatment are divided into eight stages, each lasting one week (Estevam [2022]; Hall *et al.* [2018]). Patients are instructed to maintain a routine and perform the exercises three times daily: in the morning, afternoon, and evening.

For each exercise session, 25 pelvic muscle contractions are performed, divided into two exercises. For example, Exercise 1: “Quickly contract and relax the pelvic muscles 15 times in a row”; Exercise 2: “Contract the pelvic muscles strongly 10 times, holding the contraction for 5 seconds and relaxing for 10 seconds”. This division allows for breaks during the execution of the 25 contractions and variation in the duration of contraction and muscle relaxation.

As per the booklet’s recommendations, it is suggested that the patient perform a maximum of 300 contractions per day (a number indicated in the literature to prevent muscle fatigue). Therefore, the sessions are divided into three sets of 100 contractions daily, totaling 300. To allow the patient to take breaks during the execution of the 100 contractions, the session is divided into four sets of 25 contractions each. The patient is recommended to perform 4 consecutive sets in a practice session in the morning, four sets during the afternoon practice, and four sets during the evening practice, totaling 100 contractions in each period and 300 contractions overall per day. Since muscular profiles vary from patient to patient, a minimum interval of at least 3 hours between each practice is defined to prevent muscle fatigue.

Each stage of the treatment is designed to increase the level of difficulty and complexity for exercise execution as the patient progresses weekly: in the first and second weeks, pelvic exercises are performed lying down; during the third and fourth weeks, exercises are done sitting; in the fifth and sixth weeks, exercises are performed standing, still, with legs slightly apart; finally, in the seventh and eighth weeks, exercises are done while walking.

2.2 Self-Care and mHealth

Self-care, or the care of oneself, is determined by the set of actions that an individual applies for self-care, acting individually to maintain health, cope with existing diseases, and also prevent illnesses (Rezende *et al.* [2021]; Bowman *et al.* [2004]; Dias *et al.* [2018]). This practice includes personal care regarding hygiene, nutrition, lifestyle, and environmental and socioeconomic factors (Rocha *et al.* [2016]). Knowledge about the needs of one’s own body is necessary so that the patient can know how to act appropriately when faced with events that illnesses or bad habits may cause (Silva *et al.* [2009]).

In the research conducted by Bochicchio *et al.* [2019], the authors compared a group of patients who used a reminder app to assist them in their daily medication intake with a group that continued their medication routine through conventional means. The research concluded that patients who used medication reminder apps demonstrated better medication adherence than those who continued with their usual care.

As defined by the World Health Organization [2015]

(WHO), Mobile Health (mHealth) is the medical practice supported by mobile devices, such as patient monitoring devices, smartphones, tablets, and other devices, including the use of wireless communication services and Global Positioning System (GPS). The term mHealth was first defined in the scientific literature in 2000 in the research Laxminarayan and Istepanian [2000] as “wireless e-med”.

Despite the importance of mHealth applications in contributing to self-care, healthcare providers are hesitant to prescribe the use of apps that lack evidence of their benefits, reliability for ensuring information security, and guidance on their use in clinical practices (Aitken and Gauntlett [2013]). mHealth applications must undergo rigorous clinical and technical testing before fully integrating into clinical care Bochicchio *et al.* [2019].

2.3 Gamification

The term gamification is defined as the use of game dynamics and mechanics to engage people, solve problems, and enhance learning by motivating actions and behaviors in non-game contexts (Duggal *et al.* [2021]; van Gaalen *et al.* [2021]; Deterding *et al.* [2011]). Fullerton [2014] asserts that games have specific characteristics and are structured by players, objectives, procedures, rules, resources, conflict, limits, and outcomes. The difference between games and gamification is that gamification focuses on using game elements to engage the user and does not follow the structured rules that define a game.

The literature has no consensus on the correct term for gamification. As noted by van Gaalen *et al.* [2021], confusion about which term to use may have arisen due to the rapid growth of information and the proliferation of various types of game-based learning (e.g., serious games, simulations, gamification). Different authors have used various terms for the same concept or the same terms for other concepts.

One of the effects of games sought through the gamification of computer systems is the playful aspect that allows high immersion of the player in the game. Huizinga [2014] defines this immersion as a magical circle where the player departs from the “real” world, described by him as an exceptional character illustrated by an air of mystery in which the player often engages, causing the laws and customs of everyday life to lose their validity.

Psychology describes the psychoemotional state of an engaged player with the game as a state of flow. According to Chen [2007] and Chou *et al.* [2014], this state is defined by aspects such as a sense of control, a challenging activity requiring skills, clear goals, and the fusion of action and awareness. These characteristics allow the player to deliver significant personal meaning and a unique experience, consequently promoting engagement in specific actions (Oliveira and Carvalho [2020a]).

For the gamification process of software, precise knowledge of the problem and user needs is a critical factor in achieving effective gamification applicability. Stimulating users to make behavior changes towards a specific goal is the primary approach of gamification, reinforcing user motivation to accomplish the primary goal of the software (Yousefi

and Mirkhezri [2020]; Koivisto and Hamari [2019]).

In their research, Duggal *et al.* [2021] and Alqahtani *et al.* [2021], among other researchers, point out that as gamification features are applied to software, negative impacts on its usability may emerge, diverting the user's attention from the application's main objective and compromising engagement (Li *et al.* [2016]). This occurs because many software companies apply the same gamification elements, such as points systems, levels, leaderboards, and challenges, to various software types, overlooking the domain's specificities and each individual. Conversely, gamification that can adapt to users' specificities has been studied by researchers aiming to maintain user engagement with the software's core features (Oliveira and Carvalho [2020a]; Tondello *et al.* [2017]).

3 IUProst® Application: Overview

The development of IUProst® was submitted to and approved by the Research Ethics Committee of the Universidade Federal de Minas Gerais (COEP-UFMG) – CAAE: 41736921.5.0000.5149.

The software encompasses the following general objectives: enable the patient to undergo treatment independently, without the need for supervision by a healthcare professional, as the application is publicly available; instruct the patient in the correct execution of exercises; engage the patient in self-care; enhance the user's health literacy through reliable and necessary information about prostate cancer; measure the patient's progress concerning their treatment; and measure the patient's progress concerning urinary incontinence.

Consistent exercise execution is crucial for the patient's progress with the treatment. Thus, the exercise execution screen was designed with gamified elements, using a timer, vibrations, and voice as interaction feedback, providing visual and sensory stimuli. This allows the patient to know the exact moment to contract and relax their muscles and the duration of each situation.

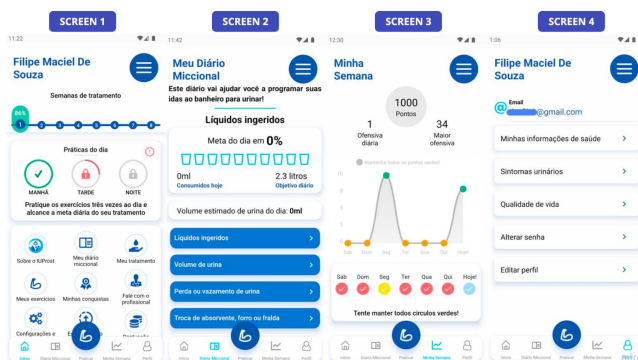


Figure 1. Main screens of IUProst® (in Portuguese).

3.1 IUProst® Versions

IUProst® was launched in October 2022 on the Play Store in version 1.0. The initial version of the application included features such as user progress feedback on their treatment and setting daily goals for fluid intake. Additionally, an algorithm was implemented to record the maximum number of

consecutive days a patient performed exercises without failure.

Version 2.0 of IUProst® was released in July 2023, featuring an exercise execution interface similar to the previous version but adding gamified elements, alert messages for rest periods, and messages about treatment, habit changes, information about prostate cancer, and RP surgery. These messages were strategically added to the application as it was noticed that patients rarely navigate to the informative screens of “My Treatment” in version 1.0.

The main distinction between version 1.0 and version 2.0 of the application lies in how treatment progress is measured. In version 1.0, the patient's progress was assessed based on the number of exercises performed, which posed a problem since the patient could complete all treatment exercises in a few days. Ideally, the patient should perform at least the minimum number of exercises over eight weeks. In version 2.0, progress is evaluated based on the days the patient performs at least three exercises. This way, the patient completes the treatment by performing the minimum number of exercises daily for 56 days (8 weeks). Days when the patient performs exercises less than three times will not be counted towards the treatment progress.

3.2 Exercise Execution

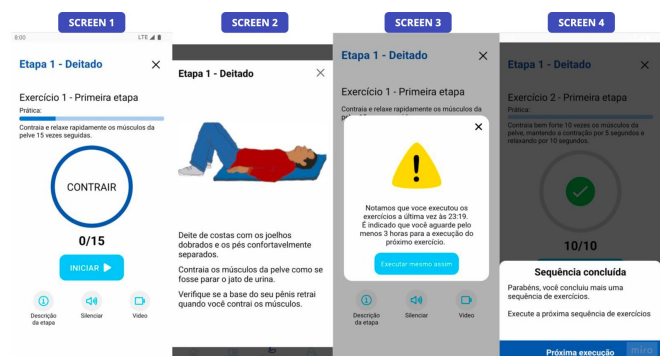


Figure 2. Exercise execution screens (in Portuguese).

Upon starting the exercise, the patient hears a voice instructing them to contract the muscles, accompanied by a double vibration from the device. Muscle contraction should be maintained for the duration (in seconds) specified by the exercise, and this time is displayed in the form of a timer circle on the application screen, which fills up during the selected seconds, as shown in Figure 2, further left.

Once the contraction time is up, the timer circle resets, and, with a single vibration, an audible alert saying “relax” is emitted, starting the countdown to maintain muscle relaxation for the time determined by the exercise. This repeats for all contractions/relaxations until the specified number of contractions is completed.

Upon completing the two exercises, a screen indicates that the execution is complete, prompting the patient to click a button to finish and save. Only exercises where the patient clicks the finish button are saved and counted, thus ensuring execution. The patient is then directed to the subsequent exercise execution to perform another 25 contractions until

completing the 100 contractions of one of the daily workouts. If they have reached the 100 contractions for the workout, due to the guidance to wait 3 hours before performing the following exercises, the patient is directed to the “My Week” screen, where their progress is displayed in graphs and cards.

3.3 Scoring System

Game elements have been incorporated throughout the application to increase the patient’s motivation to perform the exercises. These elements include achievements, a sense of progress, goals, challenges, scoring, and performance. They were created based on the information generated by the exercise practice, and they evaluate the number of executions, rest time between daily workouts, the consecutive days without failures in exercise execution, and the patient’s progress in the treatment stages.

The daily score is distributed among the daily goals for exercise practice, as mentioned in Section 2.1. The patient also earns points for completing seven consecutive days of a treatment stage without failures. The points are configured as follows:

- First daily goal: perform 100 contractions from the first set of exercises (+ 25 points);
- Second daily goal: perform the second set of exercises, completing 100 contractions (+ 25 points);
- Third daily goal: perform the third set of exercises, completing 100 contractions (+ 25 points);
- Award for completing all sets of exercises in a day (+ 25 points);
- Bonus for completing exercises for seven consecutive days in the treatment stage (+ 300 points).

The maximum score for each stage is calculated by multiplying 100 points by the number of days in the stage (seven days) and adding 300 points if the patient completes all days without fail. The patient can also lose points in the following situations:

- Performing exercises after reaching 100 contractions in one of the daily practices without waiting for the designated rest time: - 10 points for each exercise executed under this condition;
- Failing to complete one day of your treatment: - 100 points for each missed day.

The rest time is notified to the patient through components on the screens, using the color red for attention, as well as displaying alerts when the user navigates to the exercise practice screen, as shown in Figure 1, further left. The alerts are displayed to inform the user of the importance of the rest period. Still, the user is not prevented from performing the exercises since the number of exercises for muscle fatigue is relative to each patient’s physical characteristics.

4 Results and Discussion

Initially designed to assist patients in the treatment of UI with the support of healthcare professionals, IUProst® was evaluated by experts in the healthcare and computing fields us-

ing the quality models defined by the International Organization for Standardization. The research Estevam [2022] of the IUProst® research group conducted an evaluation of the software with health and computing experts. A sample of sixteen experts was considered for the product quality analysis phase, eight with experience in the UI area and eight in the software development area.

The quality analysis of the mHealth application followed the determinations of the product quality model established by the International Organization for Standardization (ISO/IEC 25010 – System and Software Engineering IEC [2014]). This model evaluates eight quality characteristics: functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability. Each of these characteristics encompasses specific sub-characteristics, resulting in a total of 22 characteristics.

All the characteristics analyzed regarding product quality showed ratings above 70%. In the analysis of the 22 subcategories, two received weak agreement (accessibility and protection against user errors), while two others received moderate agreement (maturity and recoverability). The quality characteristics evaluated in IUProst® demonstrated satisfactory results, reinforcing that the software has the technical and clinical quality to meet the needs of men with urinary incontinence after surgical treatment for prostate cancer.

Although IUProst® was proposed and evaluated for use with the support of healthcare professionals, its design and construction followed a methodology focused on developing mobile health applications for self-care solutions (de Oliveira [2018]). Therefore, upon becoming publicly available, individuals experiencing post-radical prostatectomy urinary incontinence began using it.

This study analyzes the achieved results in an uncontrolled environment, as the software does not limit the need for healthcare professionals to supervise patients during behavioral treatment execution.

From October 2022 to July 2023, the IUProst® application reached over 1,000 registered users and executed over 25,000 exercises. Of the thousand registrations, 712 users went through the stage of filling in clinical data and health information; among these, 419 users (50.6%) reported having undergone RP surgery, representing potential patients for the treatment provided by IUProst®.

The significant difference recorded between the number of registrations and the number of users who underwent surgery is believed to be due to the public nature of the application, as well as the extensive promotion due to the award received from the Brazilian Society of Biomedical Engineering² and the Blue November campaign³ in 2022. In this study, only users who underwent surgery are considered as patients.

To register for IUProst®, users must accept the Free and Informed Consent Form (FICF), which explains the study details, treatment, and data collection. After registration, users must complete forms with health, clinical, and urinary symptom information. Only after this completion does the user gain access to the main screens of the application (presented

²SBEB-Boston Scientific Award for Innovation in Biomedical Engineering for SUS - Year 2022 <https://sbeb.org.br/premio-sbeb-boston-scientific/>

³November Blue: a worldwide awareness month for prostate cancer.

in Figure 1).

4.1 Sample Space

The gamified version 2.0 of IUProst® was publicly released in early July 2023. Therefore, to understand the clinical profile of patients, their engagement in exercise execution, and their interaction with bladder diary forms, as well as to compare data generated by the first version with data from the second version of IUProst®, information was collected from the two months preceding the release of version 2.0 of the application. Thus, the data presented in this article for May and June 2023 were generated by version 1.0 of IUProst® (non-gamified), while the data for July and August 2023 correspond to version 2.0 (gamified).

Only data from patients who underwent radical prostatectomy (RP) and performed exercises during the four months considered were selected. Based on this criterion, 53 patients met the requirements, of which 31 patients performed exercises in May, 24 in June, 32 in July, and 29 in August. July and August were then compared to May and June, considering the possibility of variation in the number of patients using the application each month.

4.2 Patient Characteristics

Users must complete three mandatory forms to understand their clinical profiles upon registration. The first form, titled “Clinical Data,” asks whether the patient has undergone any treatment for urinary incontinence. Within the group of 53 analyzed patients, 20 have undergone some form of treatment for urinary incontinence. The treatment options available for selection by the patient include Acupuncture/Auriculotherapy, Electrostimulation, and Pelvic Musculature Training:

- 2 patients underwent “Electrostimulation”;
- 20 patients underwent “Pelvic Musculature Training”;
- 31 patients did not undergo any treatment.

Another question asked is whether the patient has any chronic illness or heart problem, providing three options for choice: (1) Arterial Hypertension/Blood Pressure; (2) Heart problems; and (3) Diabetes:

- 31 patients do not have any disease;
- 3 patients have diseases 1 and 2;
- 2 patients have diseases 1 and 3;
- 13 patients have disease 1;
- 1 patient has disease 2;
- 3 patients have disease 3.

Finally, patients were asked if they take any medication. For this question, three options were given: (1) Furosemide/Lasix; (2) Hydrochlorothiazide/Clorana; and (3) Spironolactone/Aldactone:

- 46 patients do not take any of these medications;
- 2 patients take medication 1;
- 5 patients take medication 2.

Among the mentioned data, it is essential to highlight that 31 out of 53 patients have never undergone any treatment for urinary incontinence. In other words, for the vast majority, IUProst® represents their first contact with treatment for this condition.

Patients are also asked about their weight and height in the clinical data form. With this information, it is possible to calculate each patient’s Body Mass Index (BMI). The BMI calculation is done as follows: $BMI = \text{weight (kg)} / (\text{height (m)} \times \text{height (m)})$. BMI classifications are defined as follows: below 18.5 - underweight; between 18.5 and 24.9 - normal weight; between 25 and 29.9 - overweight (above-desired weight); equal to or above 30 - obesity (Monteiro *et al.* [2000]).

The classification of patients’ BMI is as follows:

- 16 patients have a BMI between 18.5 and 24.9 - normal weight;
- 27 patients have a BMI between 25 and 29.9 - overweight;
- 10 patients have a BMI above 30 - obesity.

Thus, 69.8% of patients are overweight or obese. Obtaining information such as BMI, medications taken, and types of liquids the patient ingests is relevant to the treatment context, as obesity can affect the individual’s level of urinary incontinence (Poletto *et al.* [2018]).

A form was also administered to collect information on each patient’s quality of life. In this form, the following questions were asked:

1. How often do you lose urine?
2. How much urine do you think you lose?
3. In general, how much does losing urine interfere with your life? (Please choose a number between 0 – does not interfere, and 10 – interferes a lot).
4. When do you lose urine? (Please check all alternatives that apply to you).

The chart in Figure 3 presents each available option for the first question and the percentage of patients who chose each option. It can be observed that 83.4% of patients lose urine all the time or several times a day.

The second question in the quality of life form asks the patient how much urine they think they are losing. The question provides four options for selection. The chart in Figure 4 presents the patients’ responses: 98% of the answers fall into the options “a large quantity”, “a small amount”, and “a moderate amount”. In other words, most patients lose a significant amount of urine daily.

Figure 5 illustrates the third question, which asks the patient how much urinary incontinence interferes with their life, using a scale from 0 to 10. In the chart, the X-axis represents the number of responses, while the Y-axis represents the options from 0 to 10. It is observed that no patient chose option 0, highlighting that, even moderately, urinary incontinence has some negative impact on the lives of all analyzed patients.

The fourth and final question about quality of life asks the patient about the moments when they experience urine loss. This question provides eight options to the patient, representing various occasions. Among them, the possibilities

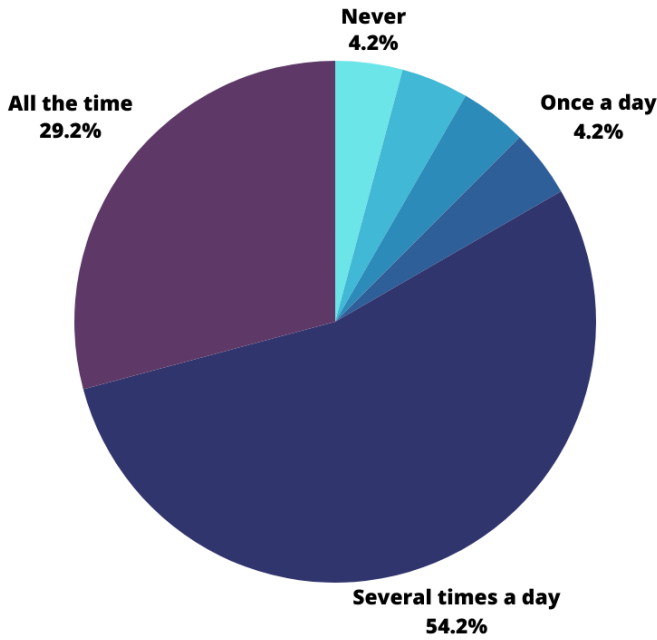


Figure 3. Quality of Life - How often do you lose urine?

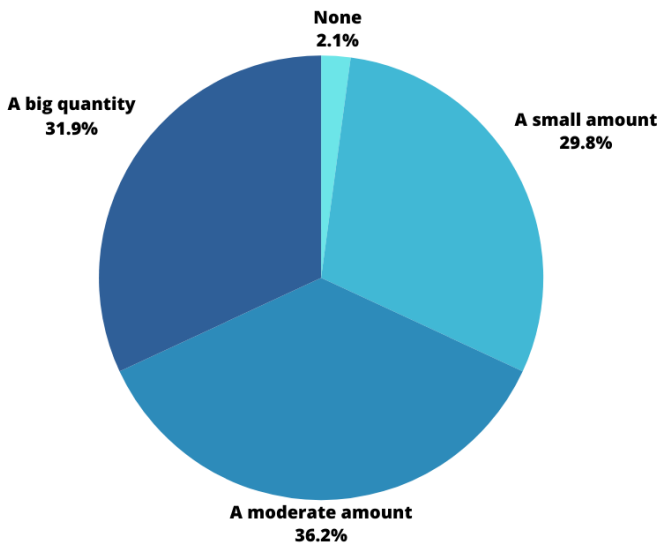


Figure 4. Quality of Life - The amount of urine you think you lose.

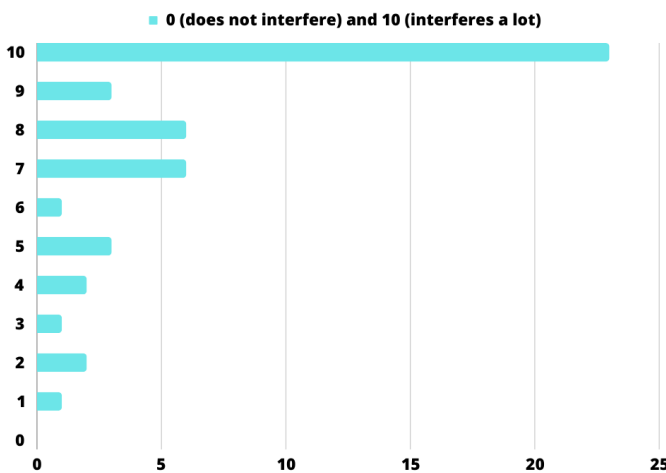


Figure 5. Quality of Life - In general, how much does losing urine interfere with your life? Please choose a number between 0 and 10.

“all the time” and “when I am doing physical activities” were

the most chosen by patients, accounting for 47.9% of the responses, as shown in Figure 6.

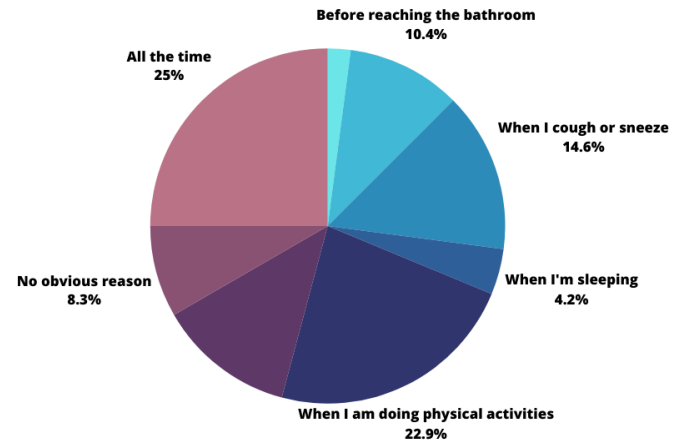


Figure 6. Quality of Life - When do you lose urine?

The presented patient quality of life data clarifies how urinary incontinence impacts each patient’s life, ensuring that the selected patients for the IUProst® usage analysis experience urinary incontinence daily.

Figure 7 presents the responses of the 48 patients to the Urinary Symptoms form. The form consists of 7 questions, each with five response options, following Likert scale definitions. The questions from P1 to P7 shown in the figure are listed below.

- P1 I can’t urinate for more than 2 hours.
- P2 I experience urine loss before reaching the bathroom.
- P3 I always use diapers due to urinary problems.
- P4 When I sit or get up from bed, I experience urine loss.
- P5 When I exert myself, such as coughing, lifting heavy objects, laughing, etc., I experience urine loss.
- P6 After standing for a long period, I experience urine loss.
- P7 When I exercise (e.g., walk), I experience urine loss.

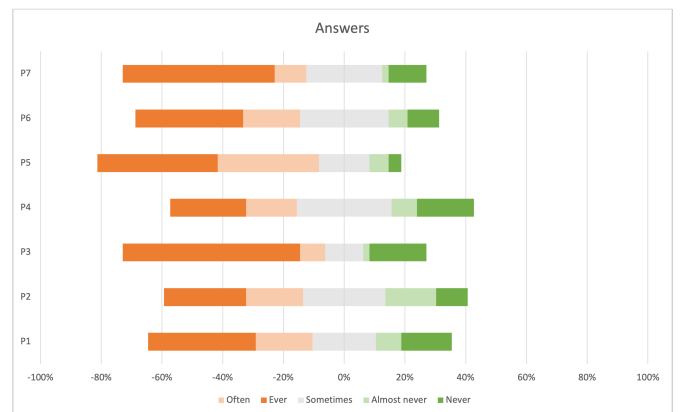


Figure 7. Responses from 53 patients to the urinary incontinence level assessment tool.

The responses obtained from patients who performed exercises over the four months contribute to demonstrating how urinary incontinence negatively affects their lives, even in simple and routine situations such as lifting objects, laughing, or exercising. In these situations, the vast majority of patients indicated experiencing urine loss almost always or always.

4.3 Patient Engagement

In January 2023, an algorithm was added to the application to record the number of consecutive days of use in the database, referred to as “daily offensives”, only the days when the patient performed the exercises at least three times, with a minimum of 75 contractions of the pelvic muscles per day (25 per practice), are considered progress in the treatment. The number of times a patient performs exercises for seven consecutive days is also called “weekly offensives”. The purpose of this addition is to encourage engagement with the application. The count of successive days was later displayed to the patient on the “My Exercises” screen, aiming to show their record for the highest number of consecutive days without failures, motivating the patient to surpass their previous mark.

From January to June 2023 (a non-gamified period since the implementation of the offensive algorithm), the five highest sequences of weekly offensives were 9, 8, 8, 6, and 6, respectively. Considering the period until August 2023, including the first two gamified months, the five highest sequences of weekly offensives were 30, 26, 23, 19, and 13, in descending order.

The daily offensives registered until June 2023 totalized 35, 31, 28, 25, and 22 consecutive days, respectively. Until August, the five highest sequences of daily offensives were 216, 153, 82, 76, and 63 straight days. If a patient fails to perform the exercise on a particular day, IUProst® 2.0 restarts their daily sequence and sets a personal goal to exceed their highest number of consecutive days by completing the minimum number of exercises.

The numbers of daily and weekly offensives mentioned show that, despite the long availability period of the offensive counter in the non-gamified version (from January to June), the number of offensives increased considerably when adding the two gamified months.

Aiming to evaluate the impact of gamification components on patient motivation, a quantitative analysis of exercise executions to contraction of the pelvic muscles was conducted in July and August, compared to the previous months (May and June). The parameters analyzed include the number of exercise executions performed in May, June, July, and August separately, the number of patients involved in exercise activities in each of these months, and the average execution of exercises per patient. Table 1 presents the values extracted from the database for each of the months under analysis.

The chart presented in Figure 8 illustrates the percentage of exercise execution for each month concerning the 120 days used in the comparison. It can be observed in Table 1 that during May, 31 patients used IUProst® and performed 1330 exercises. On the other hand, in June, despite only 24 patients using IUProst®, 3255 exercises were executed, which is 1925 more exercises compared to May.

The variation in the number of exercises between May and June is significant; however, there is a substantial jump in the number of executions between June and July, representing respectively the last month of non-gamified IUProst® and the first gamified month. August still showed a growing increase, which can be attributed to the expected delay in installing the application update on each device. Thus, the

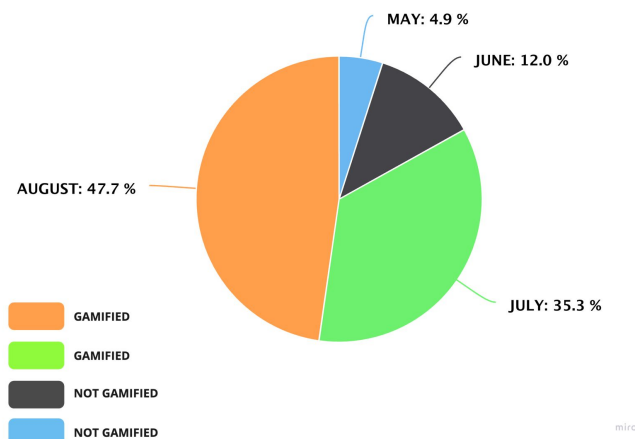


Figure 8. Performing pelvic muscle strengthening exercises from May to August.

practice of the exercises to contract the pelvic muscles during gamified IUProst® use was considerably higher, reaching 83%

The number of users who performed exercises each month can be considered similar, as it varies between 24 and 32 among the four months analyzed. Thus, these data suggest that the gamification added through scoring for the execution of the exercises and visual feedback on the progress of their daily and weekly goals prompted patient engagement with exercise execution. However, since patients do not have professional guidance to instruct them during exercise practice, it is necessary to include tools to assess the patient’s understanding of how exercises should be performed, ensuring the best possible quality in execution.

4.4 Bladder Diary

As presented in Section 2.1, the bladder diary is a fundamental part of urinary incontinence treatment. It allows a better understanding of the patient’s fluid intake, the types of liquids consumed, the routine concerning incontinence, and the level of incontinence.

Little has been modified regarding the diary between the non-gamified and gamified versions of IUProst®. Both versions have the daily fluid consumption goal as the only gamification component.

To determine the frequency of bladder diary entries, the same sample space of the last 120 days from the previous section was used. Specifically, May, June, July, and August were considered.

In May, the bladder diary recorded 172 entries, 16 of which were made in 16 days. In June, 18 entries were made in only 4 days, 108 entries were made in 16 days in July, and 349 entries were made in 20 days in August. Considering all 53 patients who used IUProst® during the 120 days from May to July, only 18 made diary entries, and only 38 days received entries from these patients. It is important to reinforce that the patient should make multiple entries in each of the four diary forms during the first three days of treatment.

These details demonstrate a low patient adherence to the routine of entering information into the diary whenever they consume liquids, change absorbents or diapers, lose urine, and report the volume of evacuated urine.

Month	Number of patients	Exercises performed	Average per patient	Percentage
May	31	1330	42 in 30 days	4.92%
June	24	3255	135,6 in 30 days	12%
July	32	9559	298,7 in 30 days	35.3%
August	29	12897	444,7 in 30 days	47.7%
Total	53	27041	510,2 in 120 days	100%

Table 1. Number of exercise executions every 30 days.

Entries in the bladder diary are crucial for the proposed incontinence treatment since most patients demonstrate difficulty in controlling urine flow, as presented in Section 4.2. Only 33 of these patients made any entries, and on most days, there were no entries from any of the 33 patients who had been using the diary. This information is relevant for future project directions, as behavioral treatment combines a commitment to exercise execution and lifestyle change, considering factors such as obesity, the patient’s existing conditions, and the types of medications used.

The public and accessible nature of IUProst and the uncontrolled patient environment, where a healthcare professional does not monitor them, make it evident the need to apply techniques to increase engagement in self-care and motivate patients to provide information continuously in the bladder diary. One option to address this issue is to implement gamification components at strategic points in the application, as was done for exercises, thus motivating patients to enter information into the diary.

4.5 Treatment Data

Table 2 presents seven items that compose an instrument called the “Post-Radical Prostatectomy Urinary Incontinence Scale (EIUPR)”, which assesses UI considering RP as a causal factor. According to Azevedo *et al.* [2021], this is the only instrument identified in the literature to evaluate urinary incontinence in patients undergoing prostatectomy. The items indicate severity on a five-point Likert scale, where zero corresponds to “never”, and four corresponds to “always” (Azevedo *et al.* [2021]; Izidoro and Soares [2021]). The total score ranges from 0 to 28, with higher scores indicating greater severity (Mata *et al.* [2022]).

Considering the questions described in Table 2, Figure 9 presents the responses of patients who completed the treatment, i.e., performed the exercises for two months. The questions were answered immediately after registering on the application and, subsequently, upon reaching the equivalent of 8 weeks of performing the exercises. IUProst® displays the initial forms again to collect clinical data, urinary symptoms, and quality of life. A total of 11 (eleven) patients responded, represented by the letters A to K. Seven of them showed a subtle improvement in the urinary incontinence scale, as depicted in Figure 9; patients H and J experienced a worsening of their symptoms. The responses of patient F when filling out the initial forms were all “never”. It is believed that this may have occurred due to some application error during the filling process.

The improvement achieved by patients A, B, C, D, G, I, and K may be related to both the patient’s engagement with the treatment and understanding of how to perform the exer-

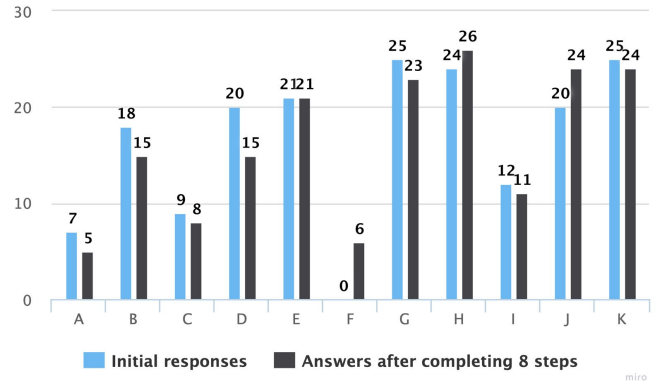


Figure 9. Incontinence scale of patients who completed the treatment. Each letter represents a patient.

cises, changes in lifestyle and diet habits, as well as factors such as illnesses, obesity, sedentary lifestyle, advanced age, and postoperative time (Izidoro *et al.* [2022]; Azevedo *et al.* [2021]).

In contrast to Figure 9, which shows the responses of the urinary incontinence assessment tool for each patient, Figure 10 presents the responses at the beginning of the treatment and after eight weeks (60 days) for each question. A slight improvement in the responses to each question is evident upon comparing the two graphs, particularly in the decrease in extreme cases, as indicated by the dark orange color in the graphs.

Figure 11 displays the number of times each patient practiced the exercises, where each practice corresponds to a combination of two exercises, totaling 25 contractions per execution.

In version 1.0 of IUProst®, if patients followed the treatment as indicated, performing three sequences of 2 exercises per day (totaling six per day), a complete treatment cycle would be completed in 56 days.

To align with the literature (Azevedo *et al.* [2021]; Izidoro *et al.* [2022]; Izidoro and Soares [2021]), version 2.0 modified the method of measuring patient progress to consider progress only on days when the patient performs the minimum number of exercises (three executions per day).

Figure 12 displays the number of days each patient performed exercises in blue and the arithmetic average of exercises executed per day in black. The figure shows the daily and weekly exercises practiced by each patient who completed eight weeks of treatment. None of the patients reached the 56 consecutive days mark. Patient G came closest to this expected mark. On the other hand, patients B, C, E, G, H, and I completed exercises for at least seven consecutive days on at least eight occasions.

Figure 12 shows the days each patient performed exercises in blue and the arithmetic average of exercises executed per

Items	Severity				
	Never	Almost never	Sometimes	Often	Ever
1. I can't go more than 2 hours without urinating.	0	1	2	3	4
2. Before reaching the bathroom, I have urine leakage.	0	1	2	3	4
3. I always wear diapers due to urinary problems.	0	1	2	3	4
4. When I sit or get out of bed, I experience urine leakage.	0	1	2	3	4
5. When I exert effort, such as coughing, lifting heavy objects, laughing, etc., I experience urine loss.	0	1	2	3	4
6. After standing for a long period, I experience urine loss.	0	1	2	3	4
7. When I exercise (e.g., walk), I experience urine leakage.	0	1	2	3	4

Table 2. Post-radical prostatectomy urinary incontinence scale.

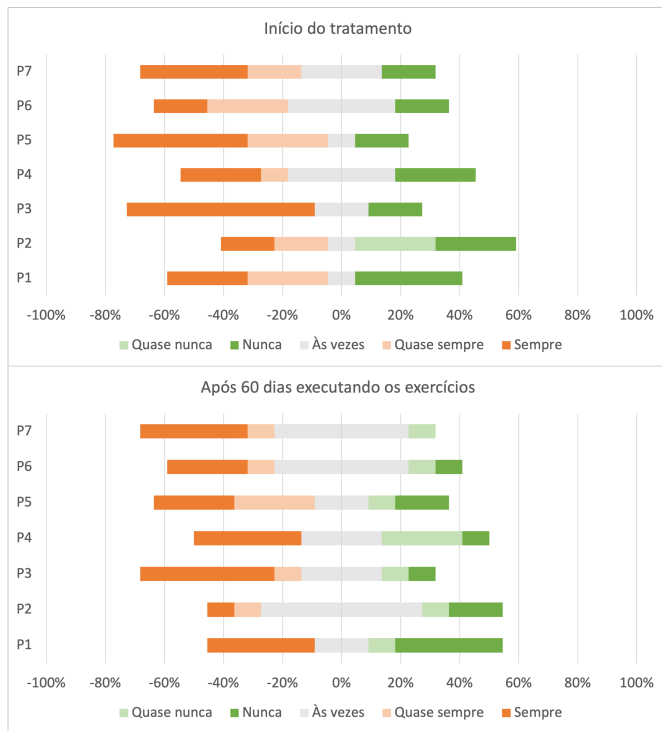


Figure 10. Initial and final responses of the 11 patients per question.

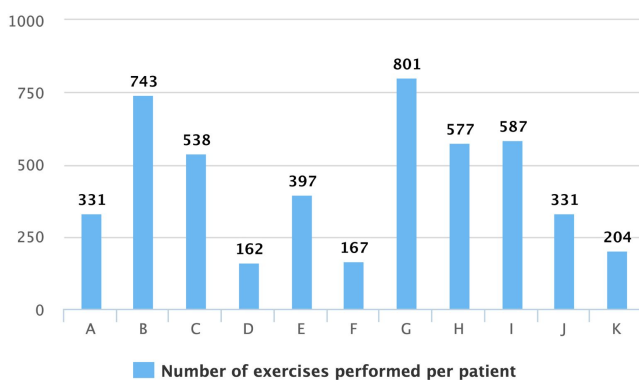


Figure 11. Number of exercises executed per patient.

day in black.

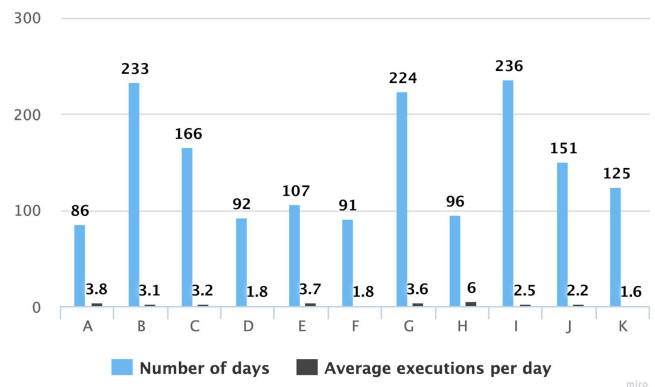


Figure 12. Number of days and average execution per patient.

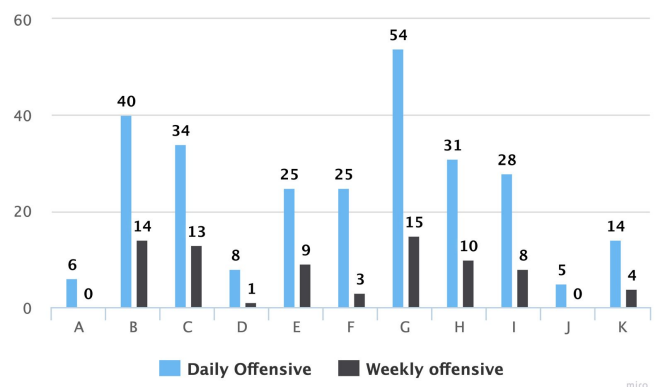


Figure 13. Patient offensives in exercise execution.

Figure 13 shows the daily and weekly practices of the exercises for each patient who completed eight weeks of treatment. None of the patients reached the 56 consecutive days mark. Patient G came closest to this expected mark. On the other hand, patients B, C, E, G, H, and I completed exercises for at least seven consecutive days on at least eight occasions. The data shown in the figures of this subsection indicate

that patients performed exercises on a considerable number of days. This pattern occurred because the treatment completion form was applied only after the release of version 2.0 of the application. The ideal scenario for comparing and understanding the patient's progress regarding incontinence would be to analyze the progress of patients who completed the treatment by performing exercises with minimal failures over the eight weeks.

5 Conclusion

The IUProst® application has demonstrated its relevance as a tool for behavioral treatment, reaching over a thousand downloads and benefiting hundreds of individuals affected by urinary incontinence. The data generated from the application's daily use cover the period from November 2022 to August 2023 and provide valuable insights into understanding each user's progress in treatment, the software's performance in achieving its purpose, and potential correlations between usability, usage frequency, and each patient's improvement.

Based on the data analysis, it can be concluded that the availability of the gamified version of IUProst® in the last two months led to a significant increase in patients' daily exercise frequency. However, upon examining the number of exercise practices by these patients and their progress in controlling urinary incontinence, it is apparent that although many patients completed the eight weeks of treatment, the improvement in incontinence was only subtle.

The literature emphasizes the quantity and the quality of exercise execution (Fitts and Posner [1967]; Hodges *et al.* [2020]; Overgård *et al.* [2008]; Izidoro *et al.* [2022]; Azevedo *et al.* [2021]). Ensuring that patients perform exercises correctly represents a significant challenge for a mHealth application-based treatment, as these patients lack the guidance of healthcare professionals to instruct them in exercise execution.

Some of the data analyzed in this article were generated by patients who have been doing the treatment exercises since the application was publicly available, i.e., since November 2022. For this reason, some patients have already performed exercises for a period exceeding the required treatment time. For a more accurate analysis of patient progress regarding incontinence, collecting data from patients who have completed the treatment as close as possible to 60 consecutive days and performing at least the minimum amount of exercises correctly will be necessary.

All of this data indicates areas where improvements can be made to IUProst®. These include (i) gathering information about the patient's comprehension of exercise practices, (ii) determining if the patient is experiencing any difficulties related to exercise execution, (iii) encouraging the patient to use the bladder diary to gain a better understanding of their incontinence routine; and (iv) consistently providing the patient with information about treatment and lifestyle changes.

In the future, comparing patients who receive support and guidance from healthcare professionals and those who undergo independent treatment could provide direct answers about the effectiveness of computational techniques applied

to IUProst®. The aim is to guide the patient towards treatment success.

Adapting behavioral treatment for urinary incontinence to the mHealth application format requires understanding and correlating application usage data with patient progress in treatment. Future research related to IUProst® should focus on these essential steps.

Despite the application's public nature, its source code is not publicly available; thus, only members of the development research group can access and use it. The collected data, being sensitive information, are treated with the utmost confidentiality and in compliance with the Brazilian General Data Protection Law (LGPD).

Declarations

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Authors' Contributions

The first and the third authors are masters in Computer Science and Nursing, whose dissertations were developed in the research area of this article. The second and fourth authors are PhD students in Computer Science working in the research area of the article. The fifth and sixth authors are supervisors guiding all the work, including the necessary revisions and adjustments.

References

- Abrams, P., Cardozo, L., Wagg, A., and Wein, A. (2017). *Incontinence*, volume 6. Tokio: Health Publications Ltd.
- Aitken, M. and Gauntlett, C. (2013). Patient apps for improved healthcare: from novelty to mainstream. In *Parissipany, NJ: IMS Institute for Healthcare Informatics*.
- Alqahtani, F., Meier, S., and Orji, R. (2021). Personality-based approach for tailoring persuasive mental health applications. *User Modeling and User-Adapted Interaction*, pages 1–43. DOI: <https://doi.org/10.1007/s11257-021-09289-5>.
- Anjos, F., Carvalho, S., Oliveira, H., Mata, L., and Estevam, F. (2022). Iuprost: Gamificação de aplicação mhealth para tratamento da incontinência urinária causada pela prostatectomia radical. In *Congresso Brasileiro de Informática em Saúde*, pages 99–104, São Paulo. DOI: https://doi.org/10.5753/sbcas_estendido.2024.2824.
- Anjos, F. M. S., Oliveira, H. M., Estevam, F. E., de Carvalho, S. T., and da Mata, L. R. F. (2023). Tratamento comportamental da incontinência urinária por meio de uma aplicação mhealth gamificada: primeiros resultados. In *Anais Estendidos do XXII Simpósio Brasileiro de Jogos e Entretenimento Digital*, pages 1–11. SBC. DOI: https://doi.org/10.5753/sbgames_estendido.2023.234181.
- Azevedo, C. *et al.* (2021). *Efetividade da acupuntura auricular associada ao treinamento muscular pélvico para controle da incontinência urinária pós-prostatectomia radical: ensaio clínico randomizado*. PhD thesis, UFMG.

- Bernardes, M. F. V. G., Chagas, S. d. C., Izidoro, L. C. d. R., Veloso, D. F. M., Chianca, T. C. M., and Mata, L. R. F. d. (2019). Impact of urinary incontinence on the quality of life of individuals undergoing radical prostatectomy. *Revista Latino-Americana de Enfermagem*, 27. DOI: <https://doi.org/10.1590/1518-8345.2757.3131>.
- Bohicchio, M. A., Vaira, L., Mortara, A., and De Maria, R. (2019). A preliminar analysis and comparison of international projects on mobile devices and mhealth apps for heart failure. pages 280–285. DOI: <https://doi.org/10.1109/EXPAT.2019.8876548>.
- Bowman, D., Kruijff, E., LaViola Jr, J. J., and Poupyrev, I. P. (2004). *3D User interfaces: theory and practice, CourseSmart eTextbook*. Addison-Wesley.
- Bucchiarone, A., Cicchetti, A., and Marconi, A. (2019). Gdf : A gamification design framework powered by model-driven engineering. In *Proceedings - 2019 ACM/IEEE 22nd International Conference on Model Driven Engineering Languages and Systems Companion, MODELS-C 2019* :, pages 753–758. Institute of Electrical and Electronics Engineers Inc.. DOI: <https://doi.org/10.1109/MODELS-C.2019.00117>.
- Chen, J. (2007). Flow in games (and everything else). *Communications of the ACM*, 50(4):31–34. DOI: <https://doi.org/10.1145/1232743.1232769>.
- Chou, J., Hung, C., and Hung, Y. (2014). Design factors of mobile game for increasing gamer’s flow experience. In *2014 IEEE International Conference on Management of Innovation and Technology*, pages 137–139. IEEE. DOI: <https://doi.org/10.1109/ICMIT.2014.6942414>.
- de Oliveira, L. W. (2018). Framework 1 para desenvolvedores de mhealth no contexto de self-care e gamificação. Master’s thesis, UFG.
- Deterding, S., Sicart, M., Nacke, L., O’Hara, K., and Dixon, D. (2011). Gamification. using game-design elements in non-gaming contexts. In *CHI ’11 Extended Abstracts on Human Factors in Computing Systems*, CHI EA ’11, page 2425–2428, New York, NY, USA. Association for Computing Machinery. DOI: <https://doi.org/10.1145/1979742.1979575>.
- Dias, L. P. S., Barbosa, J. L. V., and Vianna, H. D. (2018). Gamification and serious games in depression care: A systematic mapping study. *Telematics and Informatics*, 35(1):213–224. DOI: <https://doi.org/10.1016/j.tele.2017.11.002>.
- Duggal, K., Gupta, L. R., and Singh, P. (2021). Gamification and machine learning inspired approach for classroom engagement and learning. *Mathematical Problems in Engineering*, 2021. DOI: <https://doi.org/10.1155/2021/9922775>.
- Estevam, F. E. B. (2022). Iuprost: Aplicativo móvel para controle da incontinência urinária em homens submetidos à prostatectomia radical. Master’s thesis, UFMG.
- Fitts, P. M. and Posner, M. I. (1967). *Human performance*. Brooks/Cole.
- Frawley, H. C., Dean, S. G., Slade, S. C., and Hay-Smith, E. J. C. (2017). Is pelvic-floor muscle training a physical therapy or a behavioral therapy? a call to name and report the physical, cognitive, and behavioral elements. *Physical therapy*, 97(4):425–437. DOI: <https://doi.org/10.1093/ptj/pzx006>.
- Fullerton, T. (2014). *Game design workshop: a playcentric approach to creating innovative games*. CRC press.
- Hall, L. M., Aljuraifani, R., and Hodges, P. W. (2018). Design of programs to train pelvic floor muscles in men with urinary dysfunction: systematic review. *Neurourology and Urodynamics*, 37(7):2053–2087. DOI: <https://doi.org/10.1002/nau.23593>.
- Hodges, P. W., Stafford, R. E., Hall, L., Neumann, P., Morrison, S., Frawley, H., Doorbar-Baptist, S., Nahon, I., Crow, J., Thompson, J., et al. (2020). Reconsideration of pelvic floor muscle training to prevent and treat incontinence after radical prostatectomy. In *Urologic Oncology: Seminars and Original Investigations*, volume 38, pages 354–371. Elsevier. DOI: <https://doi.org/10.1016/j.urolonc.2019.12.007>.
- Huizinga, J. (2014). *Homo ludens* 86. Routledge.
- IEC, I. (2014). Iso/iec 25010: Systems and software engineering-systems and software quality requirements and evaluation (square)-guide to square. *Switzerland: ISO*.
- INCA (2022). *Estimativa 2020: Incidência de Câncer no Brasil*, volume 1. INCA.
- Izidoro, L. C. d. R., Mata, L. R. F. d., Azevedo, C., Paula, A. A. P. d., Pereira, M. G., Santos, J. E. M. d., Brasil, V. V., and Oliveira, L. M. d. A. C. (2022). Programa cognitivo-comportamental para controle de sintomas do trato urinário inferior pós-prostatectomia radical: ensaio clínico randomizado. *Revista Brasileira de Enfermagem*, 75. DOI: <https://doi.org/10.1590/0034-7167-2021-0818pt>.
- Izidoro, L. C. d. R. and Soares (2021). *Efetividade de programa cognitivo comportamental para controle da incontinência e melhoria de qualidade de vida após prostatectomia radical: um estudo piloto*. PhD thesis, UFG - Goiânia.
- Koivisto, J. and Hamari, J. (2019). The rise of motivational information systems: A review of gamification research. *International Journal of Information Management*, 45:191–210. DOI: <https://doi.org/10.1016/j.ijinfomgt.2018.10.013>.
- Laxminarayan, S. and Istepanian, R. S. (2000). Unwired e-med: the next generation of wireless and internet telemedicine systems. *IEEE Transactions on Information Technology in Biomedicine*, 4(3):189–193. DOI: <https://doi.org/10.1109/TITB.2000.5956074>.
- Li, C., Rusák, Z., Horváth, I., and Ji, L. (2016). Development of engagement evaluation method and learning mechanism in an engagement enhancing rehabilitation system. *Engineering Applications of Artificial Intelligence*, 51:182–190. DOI: <https://doi.org/10.1016/j.engappai.2016.01.021>.
- Mata, L. R. F. d., Azevedo, C., Menezes, A. C., Chagas, S. d. C., Izidoro, L. C. d. R., Estevam, F. E. B., and Chianca, T. C. M. (2022). Adaptação transcultural e validação da urinary incontinence scale after radical prostatectomy para o contexto brasileiro. *Revista Gaúcha de Enfermagem*, 43. DOI: <https://doi.org/10.1590/1983-1447.2022.20210163.pt>.
- Monteiro, P. O. A., Victora, C. G., Barros, F. C., and Tomasi,

- E. (2000). Diagnóstico de sobrepeso em adolescentes: estudo do desempenho de diferentes critérios para o índice de massa corporal. *Revista de Saúde Pública*, 34(5):506–513.
- Mungovan, S. F., Carlsson, S. V., Gass, G. C., Graham, P. L., Sandhu, J. S., Akin, O., Scardino, P. T., Eastham, J. A., and Patel, M. I. (2021). Preoperative exercise interventions to optimize continence outcomes following radical prostatectomy. *Nature Reviews Urology*, 18(5):259–281. DOI: <https://doi.org/10.1038/s41585-021-00445-5>.
- Oliveira, H., Anjos, F., Estevam, F., Mata, L., and Carvalho, S. (2022). Iuprost: uma aplicação móvel em saúde para apoio ao tratamento de incontinência urinária pós-prostatectomia radical. In *Congresso Brasileiro de Informática em Saúde*, pages 143–148, São Paulo.
- Oliveira, L. and Carvalho, S. (2020a). A gamification-based framework for mhealth developers in the context of self-care. In *2020 IEEE 33rd International Symposium on Computer-Based Medical Systems (CBMS)*, pages 138–141. DOI: <https://doi.org/10.1109/CBMS49503.2020.00033>.
- Oliveira, L. W. and Carvalho, S. T. (2020b). A gamification-based framework for mhealth developers in the context of self-care. pages 138–141. DOI: <https://doi.org/10.1109/CBMS49503.2020.00033>.
- Organization, W. H. (2015). *A practical guide for engaging with mobile operators in mHealth*. World Health Organization.
- Overgård, M., Angelsen, A., Lydersen, S., and Mørkved, S. (2008). Does physiotherapist-guided pelvic floor muscle training reduce urinary incontinence after radical prostatectomy?: a randomised controlled trial. *European urology*, 54(2):438–448. DOI: <https://doi.org/10.1016/j.eururo.2008.04.021>.
- Poletto, J. E., Rizzo, D. T., Baltieri, L., Cazzo, E., and Chaim, É. A. (2018). Influência da obesidade e das medidas antropométricas sobre a incontinência urinária e a qualidade de vida: um estudo piloto. *RBONE-Revista Brasileira de Obesidade, Nutrição e Emagrecimento*, 12(75):901–907.
- Rezende, M. F. C., Oliveira, L. W., and Carvalho, S. T. (2021). Gamificação e autocuidado no tratamento do diabetes tipo 2. In *Anais Estendidos do XXI Simpósio Brasileiro de Computação Aplicada à Saúde*, pages 139–144. SBC. DOI: <https://doi.org/10.5753/sbcas.2021.16115>.
- Rocha, T. A. H., Fachini, L. A., Thumé, E., Silva, N. C. d., Barbosa, A. C. Q., Carmo, M. d., and Rodrigues, J. M. (2016). Saúde móvel: novas perspectivas para a oferta de serviços em saúde. *Epidemiologia e Serviços de Saúde*, 25:159–170. DOI: <https://doi.org/10.5123/S1679-49742016000100016>.
- Silva, I. d. J., Oliveira, M. d. F. V. d., Silva, S. É. D. d., Polaro, S. H. I., Radünz, V., Santos, E. K. A. d., and Santana, M. E. d. (2009). Cuidado, autocuidado e cuidado de si: uma compreensão paradigmática para o cuidado de enfermagem. *Revista da Escola de Enfermagem da USP*, 43:697–703. DOI: <https://doi.org/10.1590/S0080-62342009000300028>.
- Tondello, G. F., Orji, R., and Nacke, L. E. (2017). Recommender systems for personalized gamification. *ACM*. DOI: <https://doi.org/10.1145/3099023.3099114>.
- van Gaalen, A. E., Brouwer, J., Schönrock-Adema, J., Bouwkamp-Timmer, T., Jaarsma, A. D. C., and Georgiadis, J. R. (2021). Gamification of health professions education: a systematic review. *Advances in Health Sciences Education*, 26(2):683–711. DOI: <https://doi.org/10.1007/s10459-020-10000-3>.
- Yousefi, B. H. and Mirkhezri, H. (2020). Lean gamification canvas: A new tool for innovative gamification design process. In *2020 International Serious Games Symposium (ISGS)*, pages 1–9. IEEE. DOI: <https://doi.org/10.1109/ISGS51981.2020.9375297>.